Collaborative Development of a Virtual Environment to Support Learning in Experimental Design and Statistical Analysis

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INTRODUCTION

In this paper we describe the design and ongoing development of a virtual environment, "The Island", that allows students to design and carry out studies to support teaching and learning in statistics. We will look at how students collaborate in the development of the Island and how they can then also collaborate in its study.

The framework of the environment is a simulated population of individuals that have lived on an Island in isolation since 1779. Currently the environment is accessed online with all simulation carried out on the server side. Figure 1 shows the home screen of the web interface, presenting the user with a map of the Island and a basic menu. There are 39 villages on the Island, ranging in size from just 12 people to the largest with 2299 inhabitants. The total population of the Island is currently 9180. This is small enough to keep the simulation of the required detail manageable while still being large enough that students cannot hope to study all the Islanders.

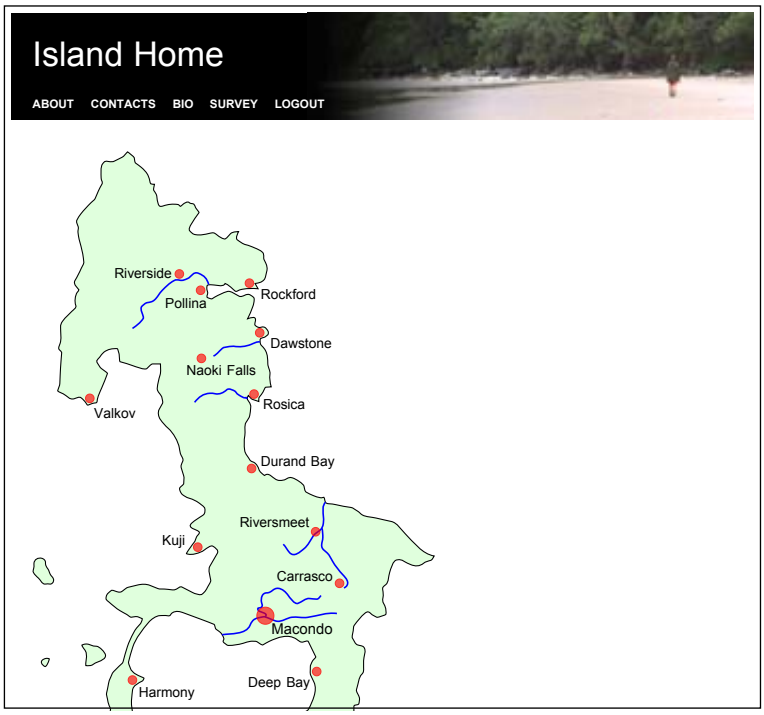

Figure 1. Main map interface to the virtual Island population

The simulation includes a model for monthly climate data with regional differences added to support student experiments, such as making it generally warmer in the north and cooler in the south of the Island (since it is notionally in the southern hemisphere). Figure 2 shows the village interface for one of the villages, obtained by clicking on a dot in the main map. The simulation runs in real time and this interface includes the current temperature as well as the times of sunrise and sunset for the day. The villages are split into hamlets of ten houses each and then each house can be home to a family of Islanders. Figure 3 shows one of these hamlets.

The different styles of house match the different cultural background of the Islanders who live in them.

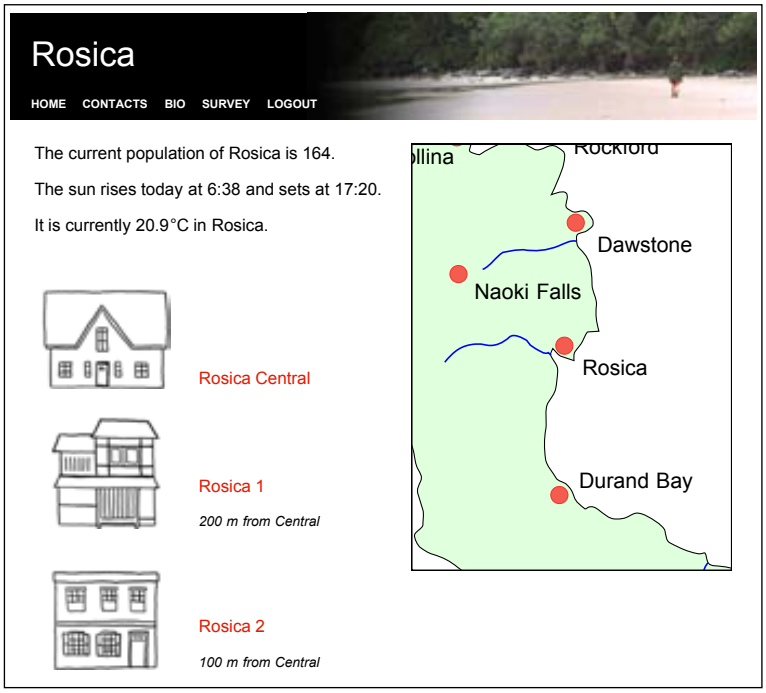

Figure 2. Information for the village of Rosica

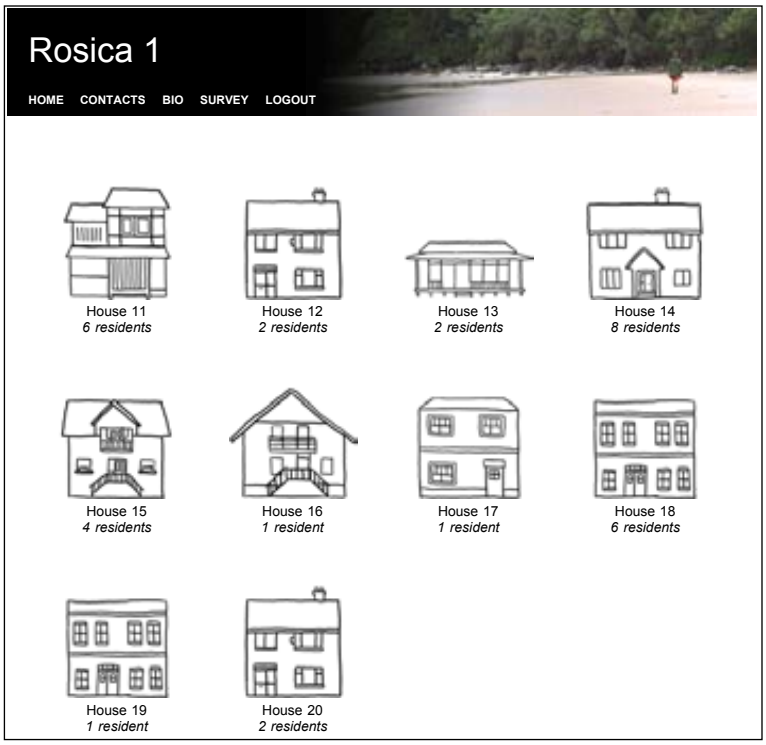

Figure 3. The ten houses in the hamlet of Rosica 1

Figure 4 shows one of the two residents in House 12, Amy Carrasco. Each Islander has their own story and a

history of parents and ancestors on the Island. This allows studies of the epidemiology of the various diseases and causes of death, including studies based on family histories as well as on the interaction with the geography of the Island. In the interface any of the small heads are links to the corresponding page for that Islander. In particular, it is easy to follow the ancestral line of an Islander by repeatedly clicking on the parent links. Pages like the one in Figure 4 are also included for the 6387 Islanders who have died on the Island since it was settled in 1779, including details of the cause of death.

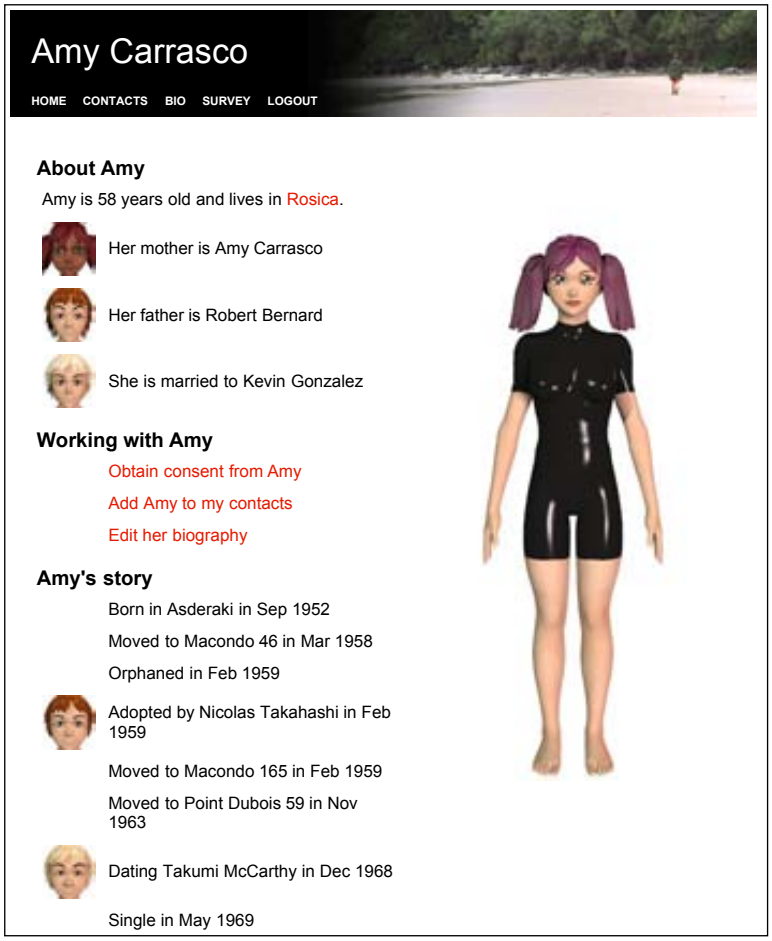

Figure 4. Amy Carrasco, a resident of Rosica, and her background story

ISLAND EXPERIMENTS

The first class where the Island was used was a statistics course for science students in 2009. While the Island framework we have described so far provided a variety of observational studies for students to consider, the focus of the statistical methods in the course was on experimental trials. To that end we wanted to extend the environment to allow the Islanders to become virtual subjects in experiments. This allowed us to overcome the ethical issues involved with students undertaking real experiments where they often wanted to use human subjects.

A key design principle has been to engage students in the creation of the Island. Instead of choosing a collection of experimental tasks for the students to use in their project work we introduced a preliminary assessment item whereby they had to make a proposal for using the Islanders in a virtual experiment. This was a valuable authentic exercise in its own right but, more importantly, it gave us a plethora of experimental tasks to incorporate into the Island simulation, tasks that we knew were of interest to the students in some way. We researched the literature around the effects of each task and the ranges of measurement outcomes,

eventually including almost all proposals in the model. Bulmer and Haladyn (2011) give more detail of this process and the modeling techniques that were used to bring the Island to life.

As can be seen in Figure 4, students first need to obtain consent from an Islander to participate in their research. If consent is granted then the student is given access to the full list of available tasks. There are currently 179 tasks that can be set for an Islander. Figure 5 shows the top of this list. The tasks can be roughly broken into treatments, such as "Light Beer 250 mL" and "Alprazolam 1mg", and measurements, such as "Blood Pressure" and "Basic Mental Arithmetic".

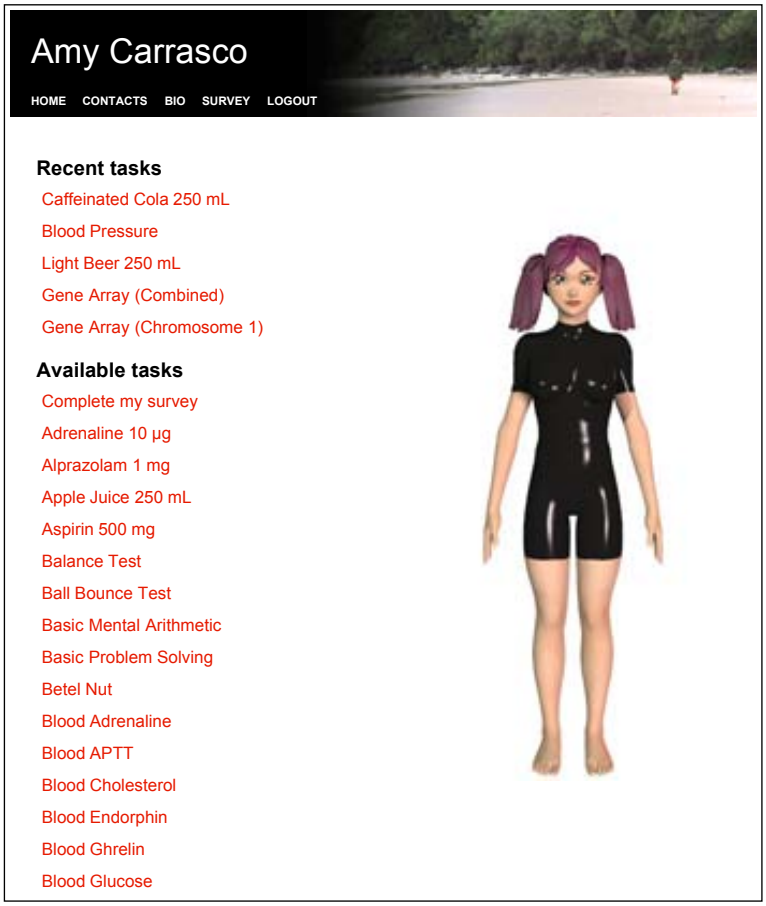

Figure 5. A selection of available experimental tasks

There is no fancy animation when an Islander drinks beer or solves some arithmetic problems since such technology is beyond the scope of the current project (and would make adding new tasks much more time consuming). Instead a simple message and progress bar is shown, as in Figure 6 where Amy is having her body temperature measured. Once the task completes any results appear under the "View Task History" link.

All tasks take time to complete and effects happen in real time. We want students to understand the value of data and we have found the easiest way to do this is to use their time as the cost. There are no tools to apply a task to multiple people at once so if the student wants to use a large number of subjects then they will have to spend a lot of time collecting data (or possibly form a group to conduct the study, as discussed in the following section). This makes topics such as power and sample size determination much more concrete and relevant in the course.

In a similar way there are no tools for collating and summarizing the data. Students need to do this themselves as it is an important skill in itself.

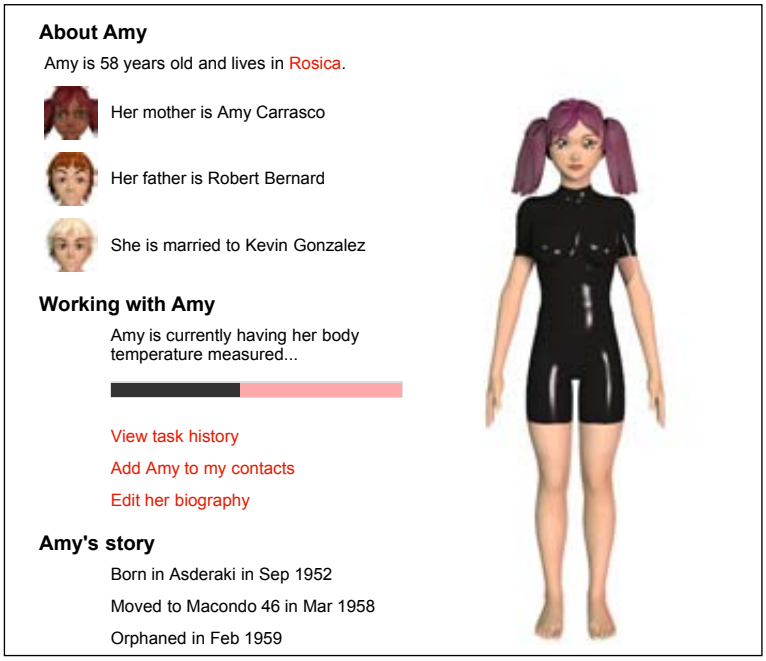

Figure 6. Amy Carrasco having her body temperature measured

GROUP PROJECTS

While not an original aim in the design of the Island, the broad scope of the virtual environment has made it natural to allow students to work in groups on their Island projects. Rather than having to assign specific roles to the group members, the groups themselves can develop the structure they need to undertake the study they have planned. For example, a group that wants to do a larger experimental study that compares Islanders from two villages might assign one person to oversee the protocol design and choice of the Islanders who will be asked to participate, two people to collect the data from each village and then a fourth person to collate and analyze the data, with all group members contributing to the writing of the paper. Instead of being told to do a project in a group of four the group of four can be chosen to best achieve the aims of the investigation.

This group formation is managed by an online system that is independent of the Island itself (since the Island is not aware in any way that the users are working in a group). Each student has a unique code that they need to give to another student if they want to form a group. The second student uses this code to apply to join the group and then waits for the first person to approve them online. The group is then formed. When another students wants to join they then apply with the same code but now all students already in the group must approve them before they are added.

Behind this mechanism are the two simple rules:

1. Students can never leave a group once they have joined it

2. All students in a group will receive the same grade from the assessment.

Rather than trying to adjust the grade based on some measure of contribution (e.g. Kaufman *et al*., 2000) the idea here is that all members of the groups have voluntarily entered into a contract with each other. Our aim is not to explicitly teach skills for group work but to show the value of working in a group. The scale of the Island environment provides a context for that value.

ISLAND COLLABORATIONS

We have made access to the Island freely available to other institutions because we are interested in extending the collaborations and bring further new ideas into the virtual environment. Here we highlight three of these collaborations and briefly outline the benefits and issues involved.

- In 2010 we had a joint grant with Ruth Crowther at the University of Queensland (Australia) and her team in the School of Population Health to use the Island as the basis for the "Development of an innovative and sustainable virtual environment that will promote student ownership and consequently enhance student engagement". This course was for students in health systems management and was not directly related to statistics yet the broad information available in the Island allowed students to conduct a needs analysis of the population. Additional survey questions were added to accommodate these requirements. One challenge was coming up with the appropriate models and data to know how the Islanders should answer these questions.

  However the main challenge was in handling the flow of time. The core Island simulation runs in real time but the effects of changes in health policy can take years to be seen. One option was to add a 'fast forward' button to the interface but this would have meant fundamental changes to the architecture and would have defeated a lot of the intentions for experimental projects in the statistics course that were mentioned earlier. Instead we introduced an interface based on time travel whereby students could add staff to the hospital 5 years ago, for example, and then see how the present had changed.

- Daniel Kaplan at Macalester College (USA) has used the Island in an introductory epidemiology course. Again the focus was not on the experimental tasks but on the underlying population of Islanders. For example, one of the projects had groups of students collecting data to estimate average life expectancy on the Island. This was interesting information since some Islanders live for well over 100 years (the oldest Islander being 254 years old!) but the result obtained from a sample of 500 Islanders was a more reasonable average life expectancy of 78 years.

- In 2011 a team including Matthew Linden, James Baglin, Anthony Bedford and Michael Nott at RMIT University (Australia) have been using the Island in three different courses covering clinical trial design, statistics and epidemiology, and analysis of medical data. This project includes extensive evaluation of the use of the Island in these courses. Results will be available in the second half of 2011.

These collaborations have all shown the potential of the Island as a general framework for integration into curricula based around human populations while also identifying the limitations of the current architecture in making this integration straightforward. These outcomes are being incorporated into the development of 'Island 2' and we welcome anyone else who would like to be involved.

ACKNOWLEDGEMENTS

We are grateful to the Apple University Consortium in Australia for an Innovation Development Grant that has provided the hardware to make the Island available to other institutions and thus foster these collaborations and further development. We thank the collaborators mentioned above for their input into the Island and thank the many students who have provided ideas for tasks and suggestions.

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ABSTRACT

We have developed a virtual environment, "The Island", that allows students to design and carry out studies to support teaching and learning in statistics. A key design principle has been to engage students in the creation of this environment. We have also made The Island available to other institutions with the aim of bringing further new ideas into the virtual environment. In this paper we will explore the benefits of this collaboration with our students and with the staff from other institutions and in other disciplines within our own institution. We will also discuss our experiences and some of the issues that have arisen from these collaborations.